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(54) **WIRELESS COUPLING OF INCOMPATIBLE NODES VIA A VIRTUAL NETWORK**
DRAHTLOSE KOPPLUNG INKOMPATIBLER KNOTEN ÜBER EIN VIRTUELLES NETZ
LIAISON SANS FIL DE NOEUDS INCOMPATIBLES VIA UN RESEAU VIRTUEL

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US-A- 5 339 316 **US-A- 5 502 726**

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Description

[0001] The invention relates to wireless coupling in information systems and, in particular, to wireless coupling of standardized information devices to non-standardized information devices.

[0002] Wireless coupling of information devices has been described in a number of publications. For example, published PCT Application Number WO 97/29605 describes a wireless virtual Local Area Network (LAN) which enables workgroup membership to be redefined without physical wiring changes. This is particularly useful, for example, to facilitate communication between remotely-located LANs and to permit ad hoc networking between a group of portable computers.

[0003] Such known wireless coupling arrangements are very useful, but they are limited to the coupling of standardized information devices, i.e. information devices that are adapted to communicate with each other in accordance with a common standard. A typical example is a network of computers that are adapted for communication over a common information bus. There are also, however, many other applications where it is desirable to establish wireless communications between standardized information devices and non-standardized information devices, i.e. information devices that are not adapted to communicate in accordance with a common standard. Non-standardized information devices include both standard-capable information devices, such as computers that have not been adapted to communicate in accordance with commonly-used standard, and standard-incapable information devices which do not have sufficient intelligence to be so adapted. Examples of typical standard-incapable information devices with which wireless communications are of particular interest are security apparatus, audio and video equipment, telephone equipment etc. Although it is possible to provide each non-standardized information device in a system with sufficient hardware to enable it to communicate in accordance with a common standard, this is an expensive and often impractical solution. It would require substantial modification of every non-standardized information device in the system.

[0004] WO 95/12942 describes using a transparent bridge between a wired and a wireless network. A forwarding database is used that contains a list of addresses associated with each subnetwork to determine how a packet should be routed.

[0005] It is an object of the invention to provide a method and apparatus for enabling economical wireless communication between standardized nodes and non-standardized nodes. As used herein:

- "node" means any device that is capable of producing, processing or utilizing information;
- "standardized node" means a node that is adapted for communicating with other nodes in accordance

with a common standard;

- "non-standardized node" means a node that is not adapted for communicating with other nodes in accordance with a common standard;
- "wireless communication" means communicating information via any energy propagation mode which is feasible for the information being communicated, including, for example, radio frequency (RF), infra-red (IR), and sonic energy propagation modes.

[0006] It is another object of the invention to provide such a method and apparatus which automatically adapts to the addition and removal of both standardized and non-standardized nodes from a wireless communication system.

[0007] In a method in accordance with the invention, wireless communication in a system including standardized nodes and non-standardized nodes is achieved by:

- establishing a virtual network including a respective virtual node representing each non-standardized node;
- communicating information between each non-standardized node and the respective virtual node in a communication format/protocol compatible with that non-standardized node;
- communicating information between each virtual node and the standardized nodes in a communication format/protocol compatible with the standardized nodes.

[0008] In an apparatus in accordance with the invention, a wireless information system is formed which includes:

- at least one non-standardized node having a transceiver for wireless communication;
- a standardized network including a bus for carrying communications between any standardized nodes that are connected to the bus;
- a wireless station including a transceiver for wireless communication with the at least one non-standardized node;
- a virtual network coupled to the wireless station and including a controller and a memory for cooperatively:
- establishing in the memory a virtual node representing each non-standardized node;
- communicating information between each non-standardized node and the respective virtual node in a communication format/protocol compatible

with the non-standardized node;

- communicating information between each virtual node and each standardized node in a communication format/protocol compatible with the standardized node.

Figure 1 is a schematic diagram illustrating an embodiment of an information system which communicates in accordance with the invention.

Figure 2 is a block diagram illustrating an embodiment of a portion of the information system of Figure 1.

[0009] The information system of Figure 1 includes a real network having standardized nodes h, p, q and a half bridge A, which is itself a standardized node; a plurality of non-standardized nodes x,y,z; a virtual network 10 having a virtual half bridge B and virtual nodes x',y',z'; and a wireless station T. Practical information systems of this type include, for example:

- an office computer system having standardized nodes including personal computers h,p,q wired for communication over a common information bus with each other and with the half bridge A; and non-standardized nodes including a printer x, a hard-disc drive y, and an image scanner z;
- a residential entertainment and security system having standardized nodes including a digital TV h, a digital VCR p, and a digital stereo system q, wired for communication over a common information bus with each other and with the half bridge A; and non-standardized nodes including a security system x, a wireless telephone y, and a loudspeaker system z.

[0010] The half bridge A controllably passes information between the real network and the virtual network. Depending on the design of the half bridge, it may also control the passage of information between the nodes h,p,q in the real network.

[0011] The non-standardized nodes x,y,z each include, in addition to a particular type of information device, a transceiver for wireless communication with the wireless station T. Each of these nodes also includes at least minimal intelligence for locally coordinating information flow between the respective information device and transceiver. Depending on the innate complexity of the particular information device, this minimal intelligence may take any one of a variety of forms, e.g. added logic hardware and/or software in an already-existing processor or microprocessor, a dedicated microprocessor, or dedicated logic hardware.

[0012] The wireless station T includes a local transceiver for wireless communication with the transceivers of nodes x,y,z and a wireless link for coordinating information flow between this local transceiver and the virtual

network. The wireless station and the non-standardized nodes x,y,z also each include a respective transducer for propagating the mode of energy chosen for wireless communication. In the exemplary embodiment shown in Figure 1, antennas are shown for propagating RF energy.

[0013] The virtual network 10 is a model that is formed with reference to the standardized half bridge A and the non-standardized nodes x,y,z. The virtual half bridge B is modeled to be complementary to the real half bridge A, such that half bridges A and B collectively form a standardized full bridge. The virtual nodes x',y',z' are modeled to represent the respective non-standardized nodes x,y,z, but modified to communicate with virtual half bridge B in the same standard as the real nodes h,p,q communicate with the real half bridge A.

[0014] Figure 2 illustrates an exemplary embodiment of a subsystem for forming the half bridge A, the virtual network 10 and the wireless station T. This subsystem includes a bridge-interface unit 20, a virtual intelligence unit 30, and the wireless station T mentioned in conjunction with the description of Figure 1.

[0015] The wireless station T includes a transceiver 12 and a wireless link 14. The transceiver is a conventional device, with the type of transceiver depending on the mode of propagation chosen for wireless communication. The wireless link 14 is also a conventional device for performing the functions of:

- converting signals received from the non-standardized nodes x,y,z, via the transceiver 12, to a format compatible with the virtual intelligence unit 30;
- converting signals received from the virtual intelligence unit to a format compatible with the transceiver and the non-standardized nodes; and
- exchanging timing and control signals with the virtual intelligence unit to effect arbitration, i.e. to coordinate the transfer of information to and from the non-standardized nodes.

The wireless link may be implemented by using, for example, a microprocessor and software for performing the format conversions. Alternatively, if the formats chosen for communication with the non-standardized nodes are not so complex as to require extensive hardware, the wireless link may be constructed by using logic circuitry. See, for example, the wireless link described in PCT Application WO 88/07794, published on 6 October 1988.

[0016] The virtual intelligence unit 30 includes a controller 32, a program memory 34 and a data memory 36. The controller, which is coupled to the wireless station T and to the bridge-interface unit 20 via a bus, may be e.g. a microprocessor, a micro-controller or a digital signal processor. The controller, under the direction of instructions in the program memory, has the capability of cooperating with the wireless station T to:

- detect the existence of any non-standardized nodes (e.g. the nodes x,y,z) that are currently capable of

- wireless communication with the virtual network;
- form virtual nodes (e.g. the nodes x', y', z') representing the detected nodes by storing in the data memory a description of each real node (x, y, z) and data which is either received from, or to be transmitted to, the respective node;
- coordinating with the wireless station to exchange communications between the virtual nodes (x', y', z') and the real nodes (x, y, z) .

[0017] Note that a variety of information may be stored in the program and data memories in association with the virtual nodes, including, for example:

- formatting information unique to each of the wireless nodes with which the station T establishes communication;
- algorithms for performing operations on data received from, or to be transmitted to, the wireless nodes;
- relative priorities for communications with the respective wireless nodes.

[0018] Note, further, that the virtual intelligence unit is easily adapted to changes in the types of non-standardized nodes with which the virtual network is to communicate. Information, e.g. program instructions and descriptive data, needed for communicating with new types of non-standardized nodes can be easily added to the program and data memories of the virtual intelligence unit.

[0019] The bridge-interface unit 20 and the virtual intelligence unit 30 cooperatively form the bridge comprising the two half bridges A and B. Half bridge A must communicate with nodes h, p, q in accordance with their common standard, while half bridge B must be capable of universally communicating with the virtual nodes x', y', z' in their respective formats. The half bridges may communicate with each other in any format common to each.

[0020] In the exemplary embodiment shown in Figure 2, the standard chosen for the real network, having the nodes h, p, q and the half bridge A, is the IEEE 1394 Standard. This standard is described in detail in the publication IEEE Std 1394-1995, "IEEE Standard for a High Performance Serial Bus" (30 August 1996). This is a particularly useful standard for high performance bus interconnection of computer peripherals and consumer electronics, including the transmission of high-speed digital video data.

[0021] Part of the half bridge A is formed by the bridge-interface unit, which includes a 1394-Standard physical layer 22 and a 1394-Standard link layer 24. Both of these layers are functional logic elements which are operationally described in the IEEE publication P1394.1 Draft 0.03, "P1394.1 Draft Standard for High Performance Serial Bus Bridges" (18 October 1997), which is

hereby incorporated by reference. The physical layer 22 includes exemplary ports 1, 2, 3 for physical connection to a common bus on which 1394-Standard nodes, e.g. the nodes h, p, q , communicate; ensures that only one node at a time transmits information on the common bus by providing an arbitration service; and converts communications received from the link layer 24 to the 1394 Standard. The link layer formats communications received from the physical layer into a standardized datagram which is addressed and framed for transmission to a predetermined one of the non-standardized nodes currently in communication with the wireless station T, i.e. node x, y or z .

[0022] The virtual intelligence unit 30 forms the remainder of the half bridge A and forms the virtual half bridge B. More specifically, the controller 32, together with the program memory 34 and the data memory 36, forms:

- a common 1394.1-Standard switching fabric (internal fabric) coupling the two half bridges; and
- the remainder of half bridge B with links to the current virtual nodes (x', y', z') .

25 Claims

1. A method of wireless communication in a system including a first network having at least one standardized node (h, p, q, A) and a second network having at least one non-standardized node (x, y, z) , said method comprising:

- a. establishing a virtual network (10) including a respective virtual node (x', y', z') representing each said non-standardized node (x, y, z) , by storing in a memory a description of said non-standardized node (x, y, z) and data which is either received from, or to be transmitted to, the respective non-standardized node (x, y, z) ; and
- b. communicating information between the at least one standardized node (h, p, q, A) and the at least one non-standardized node (x, y, z) by:

- b1. communicating information between said standardized node (h, p, q, A) and a virtual node (x', y', z') representing said non-standardized node (x, y, z) in a communication format/protocol compatible with said standardized node; and
- b2. communicating information between said virtual node (x', y', z') and the respective non-standardized node (x, y, z) in a communication format/protocol compatible with said non-standardized node.

2. A method as in claim 1, where at least one standardized node (A) comprises a real half bridge for

communicating with other standardized nodes (h,p,q) in the first network and where the virtual network (10) includes a virtual half bridge (B) for communicating with the real half bridge (A) and with the virtual nodes (x',y',z') in said standardized communication format/protocol.

3. A method as in claim 1, including determining the identity of each non-standardized node and selecting a communication format/protocol compatible with each said non-standardized node.

4. A wireless information system including:

- a. a standardized network including a bus for carrying communications between any standardized nodes (h,p,q,A) that are connected to the bus;
- b. at least one non-standardized node (x,y,z) having a transceiver for wireless communication;
- c. a wireless station (T) including a transceiver (12) for wireless communication with the at least one non-standardized node;
- d. a virtual network coupled to the wireless station and including a controller (32) and a memory (34,36) for cooperatively:

- i. establishing in the memory a virtual node representing each said non-standardized node by storing in the memory a description of said respective non-standardized node (x,y,z) and data which is either received from, or to be transmitted to, the respective non-standardized node (x,y,z);
- ii. communicating information between the at least one standardized node (h,p,q,A) and the at least one non-standardized node (x,y,z) by:

communicating information between each said standardized node and each said virtual node in a communication format/protocol compatible with said standardized node; and
communicating information between each said non-standardized node and the respective virtual node in a communication format/protocol compatible with said non-standardized node.

5. A communication node (10) for use in the wireless information system as claimed in claim 4; the communication node including:

- a. a real half bridge (A) for communicating with standardized nodes (h,p,q) in a standardized network including a bus for carrying communi-

cations between the standardized nodes (h,p,q,A) that are connected to the bus; the communication being according to a standardized communication format/protocol compatible with said standardized nodes; and

- b. a virtual network coupled to a wireless station (T) including a transceiver (12) for wireless communication with at least one non-standardized node (x,y,z) having a transceiver for wireless communication; the virtual network including a controller (32) and a memory (34,36) for cooperatively:

- i. establishing in the memory a virtual node representing each said non-standardized node by storing in the memory a description of said respective non-standardized node (x,y,z) and data which is either received from, or to be transmitted to, the respective non-standardized node (x,y,z);
- ii. communicating information between each said non-standardized node and the respective virtual node in a communication format/protocol compatible with said non-standardized node;

the virtual network further including a virtual half bridge (B) for communicating with the real half bridge (A) and with the virtual nodes (x',y',z') according to the standardized communication format/protocol.

Patentansprüche

1. Verfahren für drahtlose Kommunikation in einem System, das ein erstes Netz, das mindestens einen standardisierten Knoten (h, p, q, A) hat, und ein zweites Netz, das mindestens einen nicht standardisierten Knoten (x, y, z) hat, umfasst, wobei das Verfahren Folgendes umfasst:

- a. Einrichten eines virtuellen Netzes (10), das einen entsprechenden virtuellen Knoten (x', y', z') umfasst, der jeden der nicht standardisierten Knoten (x, y, z) darstellt, indem er in einem Speicher eine Beschreibung des nicht standardisierten Knotens (x, y, z) und Daten, die entweder von dem entsprechenden nicht standardisierten Knoten (x, y, z) empfangen werden oder an ihn zu übertragen sind, speichert; und
- b. Kommunizieren von Informationen zwischen dem mindestens einen standardisierten Knoten (h, p, q, A) und dem mindestens einen nicht standardisierten Knoten (x, y, z) durch:

- b1. Kommunizieren von Informationen zwischen dem standardisierten Knoten (h, p, q, A) und einem virtuellen Knoten (x', y', z'),

- der den nicht standardisierten Knoten (x, y, z) darstellt, in einem Kommunikationsformat/Protokoll, das mit dem standardisierten Knoten kompatibel ist; und
- b2. Kommunizieren von Informationen zwischen dem virtuellen Knoten (x', y', z') und dem entsprechenden nicht standardisierten Knoten (x, y, z) in einem Kommunikationsformat/Protokoll, das mit dem nicht standardisierten Knoten kompatibel ist.
2. Verfahren nach Anspruch 1, wobei mindestens ein standardisierter Knoten (A) eine reale Halbbrücke zum Kommunizieren mit anderen standardisierten Knoten (h, p, q) im ersten Netz umfasst und wobei das virtuelle Netz (10) eine virtuelle Halbbrücke (B) zum Kommunizieren mit der realen Halbbrücke (A) und mit den virtuellen Knoten (x', y', z') im standardisierten Kommunikationsformat/Protokoll umfasst.
3. Verfahren nach Anspruch 1, das das Bestimmen der Identität von jedem nicht standardisierten Knoten und das Auswählen eines Kommunikationsformats/Protokolls, das mit jedem der nicht standardisierten Knoten kompatibel ist, umfasst.
4. Drahtloses Informationssystem, das Folgendes umfasst:
- a. ein standardisiertes Netz, das einen Bus zum Tragen von Kommunikationen zwischen standardisierten Knoten (h, p, q, A), die mit dem Bus verbunden sind, umfasst;
- b. mindestens einen nicht standardisierten Knoten (x, y, z), der eine Sende- und Empfangseinrichtung für drahtlose Kommunikation hat;
- c. eine drahtlose Station (T), die eine Sende- und Empfangseinrichtung (12) für drahtlose Kommunikation mit dem mindestens einen nicht standardisierten Knoten umfasst; d. ein virtuelles Netz, das an die drahtlose Station gekoppelt ist und einen Controller (32) und einen Speicher (34, 36) umfasst, um zusammenwirkend:
- i. im Speicher einen virtuellen Knoten einzurichten, der jeden der nicht standardisierten Knoten darstellt, indem im Speicher eine Beschreibung des entsprechenden nicht standardisierten Knotens (x, y, z) und Daten, die entweder von dem entsprechenden nicht standardisierten Knoten (x, y, z) empfangen werden oder an ihn zu übermitteln sind, gespeichert werden;
- ii. Informationen zwischen dem mindestens einen standardisierten Knoten (h, p, q, A) und dem mindestens einen nicht standardisierten Knoten (x, y, z) zu kommunizieren durch:
- Kommunizieren von Informationen zwischen jedem der standardisierten Knoten und jedem der virtuellen Knoten in einem Kommunikationsformat/Protokoll, das mit dem standardisierten Knoten kompatibel ist; und
- Kommunizieren von Informationen zwischen jedem der nicht standardisierten Knoten und dem entsprechenden virtuellen Knoten in einem Kommunikationsformat/Protokoll, das mit dem nicht standardisierten Knoten kompatibel ist.
5. Kommunikationsknoten (10) zur Verwendung im drahtlosen Informationssystem nach Anspruch 4; wobei der Kommunikationsknoten Folgendes umfasst:
- a. eine reale Halbbrücke (A) zum Kommunizieren mit standardisierten Knoten (h, p, q) in einem standardisierten Netz, das einen Bus zum Tragen von Kommunikationen zwischen den standardisierten Knoten (h, p, q, A), die mit dem Bus verbunden sind, umfasst; wobei die Kommunikation gemäß einem standardisierten Kommunikationsformat/Protokoll erfolgt, das mit den standardisierten Knoten kompatibel ist; und
- b. ein virtuelles Netz, das mit einer drahtlosen Station (T) gekoppelt ist, die eine Sende- und Empfangseinrichtung (12) für drahtlose Kommunikation mit mindestens einem nicht standardisierten Knoten (x, y, z) umfasst, der eine Sende- und Empfangseinrichtung für drahtlose Kommunikation hat; wobei das virtuelle Netz einen Controller (32) und einen Speicher (34, 36) umfasst, um zusammenwirkend:
- i. im Speicher einen virtuellen Knoten einzurichten, der jeden der nicht standardisierten Knoten darstellt, indem im Speicher eine Beschreibung des entsprechenden nicht standardisierten Knotens (x, y, z) und Daten, die entweder von dem entsprechenden nicht standardisierten Knoten (x, y, z) empfangen werden oder an ihn zu übermitteln sind, gespeichert werden;
- ii. Informationen zwischen jedem der nicht standardisierten Knoten und dem entsprechenden virtuellen Knoten in einem Kommunikationsformat/Protokoll, das mit dem nicht standardisierten Knoten kompatibel ist, zu kommunizieren;
- wobei das virtuelle Netz ferner eine virtuelle Halbbrücke (B) zum Kommunizieren mit der realen Halbbrücke (A) und mit den virtuellen Knoten (x', y', z') gemäß dem standardisierten Kommunikationsformat/Protokoll umfasst.

Revendications

1. Procédé de communication sans fil dans un système incluant un premier réseau comportant au moins un noeud normalisé (h, p, q, A) et un second réseau comportant au moins un noeud non normalisé (x, y, z), ledit procédé comprenant :
 - a. l'établissement d'un réseau virtuel (10) incluant un noeud virtuel respectif (x', y', z') représentant chacun desdits noeuds non normalisés (x, y, z) par le stockage dans une mémoire d'une description dudit noeud non normalisé (x, y, z) et de données qui soit sont reçues du noeud non normalisé (x, y, z) respectif, soit doivent être transmises à ce noeud; et
 - b. la communication d'informations entre le au moins un noeud normalisé (h, p, q, A) et le au moins un noeud non normalisé (x, y, z) par :
 - b1. la communication d'informations entre ledit noeud normalisé (h, p, q, A) et un noeud virtuel (x', y', z') représentant ledit noeud non normalisé (x, y, z) dans un format/protocole de communication compatible avec ledit noeud normalisé; et
 - b2. la communication d'informations entre ledit noeud virtuel (x', y', z') et le noeud non normalisé (x, y, z) respectif dans un format/protocole de communication compatible avec ledit noeud non normalisé.
2. Procédé selon la revendication 1, au moins un noeud normalisé (A) comprenant un demi-pont réel pour la communication avec d'autres noeuds normalisés (h, p, q) dans le premier réseau et le réseau virtuel (10) incluant un demi-pont virtuel (B) pour la communication avec le demi-pont réel (A) et avec les noeuds virtuels (x', y', z') dans ledit format/protocole de communication normalisé.
3. Procédé selon la revendication 1, incluant la détermination de l'identité de chaque noeud non normalisé et la sélection d'un format/protocole de communication compatible avec chacun desdits noeuds non normalisés.
4. Système d'information sans fil incluant :
 - a. un réseau normalisé incluant un bus pour véhiculer les communications entre les quelconques noeuds normalisés (h, p, q, A) qui sont connectés au bus;
 - b. au moins un noeud non normalisé (x, y, z) comportant un émetteur-récepteur pour une communication sans fil;
 - c. une station sans fil (T) incluant un émetteur-récepteur (12) pour la communication sans

fil avec le au moins un noeud non normalisé;
 d. un réseau virtuel couplé à la station sans fil et incluant un contrôleur (32) et une mémoire (34, 36) pour, en coopération :

- i. établir dans la mémoire un noeud virtuel représentant chacun desdits noeuds non normalisés en stockant dans la mémoire une description dudit noeud non normalisé (x, y, z) respectif et des données qui soit sont reçues du noeud non normalisé (x, y, z) respectif, soit doivent être transmises à ce noeud;
- ii. communiquer des informations entre le au moins un noeud normalisé (h, p, q, A) et le au moins un noeud non normalisé (x, y, z) par :

la communication d'informations entre chacun desdits noeuds normalisés et chacun desdits noeuds virtuels dans un format/protocole de communication compatible avec ledit noeud normalisé; et

la communication d'informations entre chacun desdits noeuds non normalisés et le noeud virtuel respectif dans un format/protocole de communication compatible avec ledit noeud non normalisé.

5. Noeud de communication (10) à utiliser dans le système d'information sans fil selon la revendication 4; le noeud de communication incluant :
 - a. un demi-pont réel (A) pour la communication avec des noeuds normalisés (h, p, q) dans un réseau normalisé incluant un bus pour véhiculer des communications entre les noeuds normalisés (h, p, q, A) qui sont connectés au bus; la communication se faisant selon un format/protocole de communication normalisé compatible avec lesdits noeuds normalisés; et
 - b. un réseau virtuel couplé à une station sans fil (T) incluant un émetteur-récepteur (12) pour la communication sans fil avec au moins un noeud non normalisé (x, y, z) comportant un émetteur-récepteur pour la communication sans fil; le réseau virtuel incluant un contrôleur (32) et une mémoire (34, 36) pour, en coopération :

- i. établir dans la mémoire un noeud virtuel représentant chacun desdits noeuds non normalisés en stockant dans la mémoire une description dudit noeud non normalisé (x, y, z) respectif et des données qui soit sont reçues du noeud non normalisé (x, y, z) respectif, soit doivent être transmises à ce noeud;

ii. communiquer des informations entre chacun desdits noeuds non normalisés et le noeud virtuel respectif dans un format/protocole de communication compatible avec ledit noeud non normalisé;

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le réseau virtuel incluant en outre un demi-pont virtuel (B) pour communiquer avec le demi-pont réel (A) et avec les noeuds virtuels (x' , y' , z') selon le format/protocole de communication normalisé.

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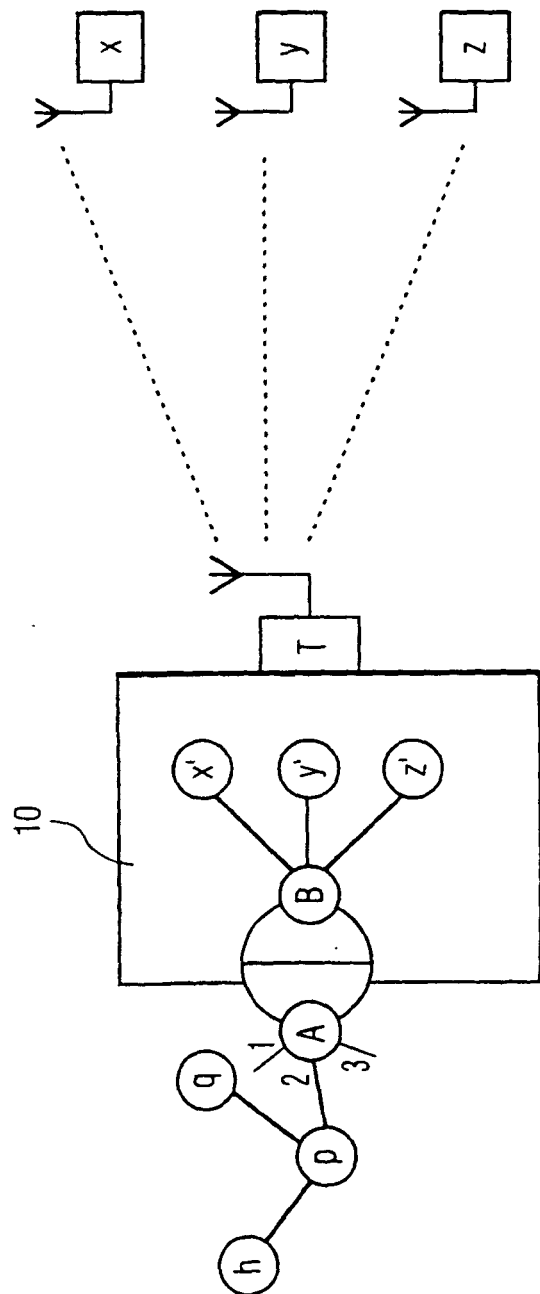


FIG. 1

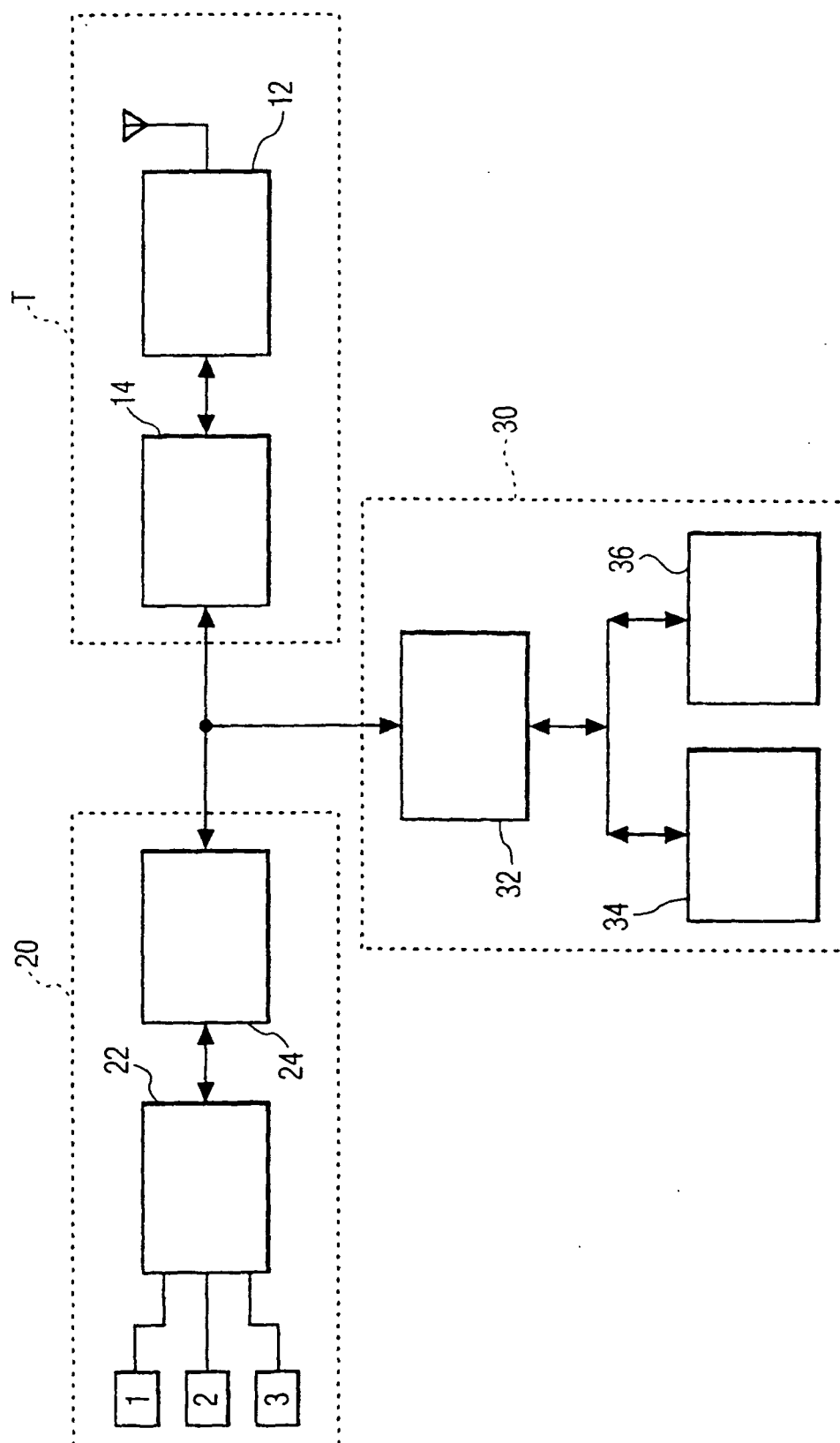


FIG. 2